

## SSNV184 - Triaxial compression test with the model of Hoek-Brown modified

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### Summarized

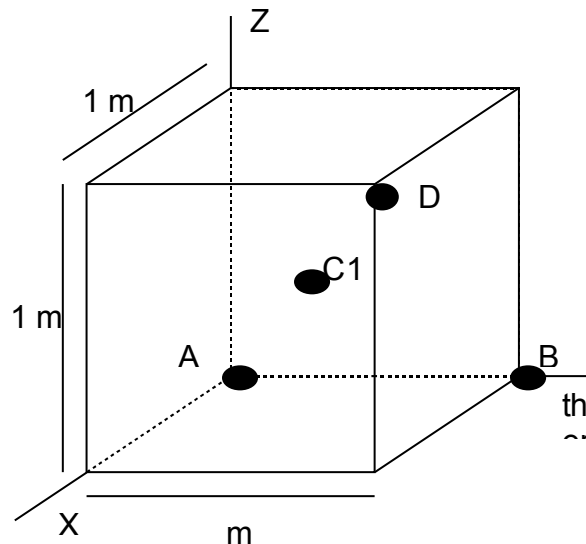
This test makes it possible to validate the elastoplastic constitutive law of Hoek-Brown modified in rock mechanics. It is about a triaxial compression test for which computations are carried out in pure mechanics. Three levels of containment are applied:  $5\text{ MPa}$  ,  $12\text{ MPa}$  and  $25\text{ MPa}$  . For reasons of symmetry, one is interested only in the eighth of a sample subjected to a triaxial compression test.

It is about a test of NON-regression.

## 1 Problem of reference

### 1.1 Geometry

One considers a cube of dimension here  $1\text{ m} \times 1\text{ m} \times 1\text{ m}$ .



Coordinated of the points (in  $m$ ):

|     | A | B    | C | D |
|-----|---|------|---|---|
| $x$ | 0 | 0.05 |   | 1 |
| $y$ | 0 | 1.05 |   | 1 |
| $z$ | 0 | 0.05 |   | 1 |

### 1.2 Properties of the material

Parameters of the elastic constitutive law:

$$E = 4500 \text{ MPa}$$

$$\nu = 0.3$$

Parameters of the model of Hoek-Brown modified:

$$\gamma^{rup} = 0.005$$

$$\gamma^{res} = 0.017$$

$$(S \sigma_c^2)^{end} = 225 \text{ MPa}^2$$

$$(S \sigma_c^2)^{rup} = 482.5675 \text{ MPa}^2$$

$$(m \sigma_c)^{end} = 13.5 \text{ MPa}$$

$$(m \sigma_c)^{rup} = 83.75 \text{ MPa}$$

$$\beta = 3 \text{ MPa}$$

$$\phi^{rup} = 15^\circ$$

$$\phi^{res} = 30^\circ$$

$$\alpha = 3.3$$

## 1.3 Initial conditions, in extreme cases and loading

the test breaks up into two phases:

- 1) Initially, one brings the sample in a homogeneous state  $\sigma_{xx}^0 = \sigma_{yy}^0 = \sigma_{zz}^0$ . For that, the corresponding confining pressure is imposed on the front sides ( $x = 1$ ), side right ( $y = 1$ ) and higher ( $z = 1$ ), while displacements are taken null on the sides postpones ( $u_x|_{x=0} = 0$ ), side left ( $u_y|_{y=0} = 0$ ) and lower ( $u_z|_{z=0} = 0$ ).
- 2) Once the homogeneous state obtained, displacements are maintained blocked on the sides postpones, side left and lower and the confining pressure is always imposed on the front sides and side right. A displacement is forced on the upper face ( $u_z(t)$ ) in order to obtain a strain  $\varepsilon_{zz}$  equal to  $-25\%$  starting from the beginning of the second phase (with  $t=2$ ). The increment of strain is taken constant:  $\Delta\varepsilon_{zz} = -2.5E - 4$  for the modelizations A and B, and  $\Delta\varepsilon_{zz} = -3.33E - 4$  for the modelization C.

## 2 Reference solution

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### 2.1 Computation of solution

the value of the major principal stress can be calculated at the breaking point ( $\gamma^{rup}$ ) and residual strength ( $\gamma^{res}$ ) from the form of the deviator of stress:

$$|\sigma_1 - \sigma_3|^{rup} = \sqrt{(S\sigma_c^2)^{rup} - \sigma_3(m\sigma_c)^{rup}}$$

$$|\sigma_1 - \sigma_3|^{res} = \sqrt{(S\sigma_c^2)^{res} - \sigma_3(m\sigma_c)^{res}} - b^{res} \left( 1 - \frac{\sigma_3}{\sigma_3^{b-d}} \right)$$

$$\text{avec } \sigma_3^{b-d} = \frac{-(m\sigma_c)^{rup} - \sqrt{((m\sigma_c)^{rup})^2 + 4(1-\alpha)^2(S\sigma_c^2)^{rup}}}{2(1-\alpha)^2} \text{ et } b^{res} = \beta - \sqrt{(S\sigma_c^2)^{rup}}$$

### 2.2 Forced results of

reference  $\sigma_{xx}(\sigma_3)$ ,  $\sigma_{yy}(\sigma_1)$  and  $\sigma_{zz}(\sigma_3)$  with the point  $D$ .

Displacements  $\varepsilon_{xx}(\varepsilon_3)$  and  $\varepsilon_{zz}(\varepsilon_1)$  at the point  $D$ .

## 3 Modelization A

### 3.1 Characteristic of the modelization

Modelization 3D

Cutting: 1m in height, 1m width

Loading of phase 1:  $\sigma_{xx}^0 = \sigma_{yy}^0 = \sigma_{zz}^0 = -5$  MPa (confining pressure)

Boundary conditions:  $u_x|_{x=0} = u_y|_{y=0} = u_z|_{z=0} = 0$

### 3.2 Characteristics of the mesh

Many nodes: 20

Number of meshes and types: 6 QUAD8 and 1 HEXA20

### 3.3 Quantities tested and Fracture

results:

Valeur de référence :  $|\sigma_1 - \sigma_3|_{ref}^{rup} = 30.0219$

Valeur du Code\_Aster :  $|\sigma_1 - \sigma_3|^{rup} = 29.7520$  (numéro d'ordre : 43)

Ecart relatif réf - Code\_Aster : 0.90 %

Residual strength:

Valeur de référence :  $|\sigma_1 - \sigma_3|_{ref}^{rup} = 15.7215$

Valeur du Code\_Aster :  $|\sigma_1 - \sigma_3|^{rup} = 15.7215$  (numéro d'ordre : 65)

| Localization   | Sequence number | Forced (MPa)  | Code_Aster      |
|----------------|-----------------|---------------|-----------------|
| Point <i>D</i> | 12              | $\sigma_{xx}$ | -5.00           |
|                | 40              | $\sigma_{xx}$ | -5.00           |
|                | 12              | $\sigma_{yy}$ | -5.00           |
|                | 40              | $\sigma_{yy}$ | -5.00           |
|                | 12              | $\sigma_{zz}$ | -18.5           |
|                | 16              | $\sigma_{zz}$ | -22.4982        |
|                | 30              | $\sigma_{zz}$ | -29.0442        |
|                | 43              | $\sigma_{zz}$ | <b>-34.7520</b> |
|                | 45              | $\sigma_{zz}$ | -31.3756        |
|                | 50              | $\sigma_{zz}$ | -24.4274        |
|                | 55              | $\sigma_{zz}$ | -21.6325        |
|                | 65              | $\sigma_{zz}$ | <b>-20.7215</b> |

| Localization | Sequence number | Strain | Code_Aster |
|--------------|-----------------|--------|------------|
|--------------|-----------------|--------|------------|

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

| Not D | 12.0.9 | $\epsilon_{xx}$ | E-3         |
|-------|--------|-----------------|-------------|
|       | 16     | $\epsilon_{xx}$ | 1.22296 E-3 |
|       | 30     | $\epsilon_{xx}$ | 2.82301 E-3 |
|       | 43     | $\epsilon_{xx}$ | 4.59944 E-3 |
|       | 45     | $\epsilon_{xx}$ | 5.39287 E-3 |
|       | 50     | $\epsilon_{xx}$ | 7.41788 E-3 |
|       | 55     | $\epsilon_{xx}$ | 9.07385 E-3 |
|       | 65     | $\epsilon_{xx}$ | 11.9257 E-3 |
|       | 12     | $\epsilon_{zz}$ | -3 E-3      |
|       | 65     | $\epsilon_{zz}$ | -16.25 E-3  |

## 4 Modelization B

### 4.1 Characteristic of the modelization

Modelization 3D

Cutting: 1m in height, 1m width

Loading of phase 1:  $\sigma_{xx}^0 = \sigma_{yy}^0 = \sigma_{zz}^0 = -12$  MPa (confining pressure)

Boundary conditions:  $u_x|_{x=0} = u_y|_{y=0} = u_z|_{z=0} = 0$

### 4.2 Characteristics of the mesh

Many nodes: 20

Number of meshes and types: 6 QUAD8 and 1 HEXA20

### 4.3 Quantities tested and Fracture

results:

Valeur de référence :  $|\sigma_1 - \sigma_3|_{ref}^{rup} = 38.5690$

Valeur du Code\_Aster :  $|\sigma_1 - \sigma_3|^{rup} = 38.4447$  (numéro d'ordre : 51)

Ecart réf - Code\_Aster : 0.32 %

Residual strength:

Valeur de référence :  $|\sigma_1 - \sigma_3|_{ref}^{rup} = 30.8023$

Valeur du Code\_Aster :  $|\sigma_1 - \sigma_3|^{rup} = 30.8023$  (numéro d'ordre : 80)

| Localization   | Sequence number | Forced (MPa)  | Code_Aster      |
|----------------|-----------------|---------------|-----------------|
| Point <i>D</i> | 16              | $\sigma_{xx}$ | -12.00          |
|                | 50              | $\sigma_{xx}$ | -12.00          |
|                | 16              | $\sigma_{yy}$ | -12.00          |
|                | 50              | $\sigma_{yy}$ | -12.00          |
|                | 16.-30          | $\sigma_{zz}$ |                 |
|                | 20              | $\sigma_{zz}$ | -33.2264        |
|                | 40              | $\sigma_{zz}$ | -44.5889        |
|                | 51              | $\sigma_{zz}$ | <b>-50.4447</b> |
|                | 55              | $\sigma_{zz}$ | -48.0512        |
|                | 60              | $\sigma_{zz}$ | -45.5579        |
|                | 70              | $\sigma_{zz}$ | -43.0472        |
|                | 80              | $\sigma_{zz}$ | <b>-42.8023</b> |

| Localization | Sequence number | Strain | Code_Aster |
|--------------|-----------------|--------|------------|
|--------------|-----------------|--------|------------|

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| Point $D$ | 16.1.2 | $\epsilon_{xx}$ | E-3         |
|-----------|--------|-----------------|-------------|
|           | 20     | $\epsilon_{xx}$ | 1.56091 E-3 |
|           | 40     | $\epsilon_{xx}$ | 3.78317 E-3 |
|           | 51     | $\epsilon_{xx}$ | 5.22869 E-3 |
|           | 55     | $\epsilon_{xx}$ | 6.32002 E-3 |
|           | 60     | $\epsilon_{xx}$ | 7.74068 E-3 |
|           | 70     | $\epsilon_{xx}$ | 10.5716 E-3 |
|           | 80     | $\epsilon_{xx}$ | 13.3372 E-3 |
|           | 16     | $\epsilon_{zz}$ | -4 E-3      |
|           | 80     | $\epsilon_{zz}$ | 2nd-2       |



## 5 Modelization C

### 5.1 Characteristic of the modelization

Modelization 3D

Cutting: 1m in height, 1m width

Loading of phase 1:  $\sigma_{xx}^0 = \sigma_{yy}^0 = \sigma_{zz}^0 = -25$  MPa (confining pressure)

Boundary conditions:  $u_x|_{x=0} = u_y|_{y=0} = u_z|_{z=0} = 0$

### 5.2 Characteristics of the mesh

Many nodes: 20

Number of meshes and types: 6 QUAD8 and 1 HEXA20

### 5.3 Quantities tested and Fracture

results:

Valeur de référence :  $|\sigma_1 - \sigma_3|_{ref}^{rup} = 50.7574$

Valeur du Code\_Aster :  $|\sigma_1 - \sigma_3|^{rup} = 50.3064$  (numéro d'ordre : 46)

Ecart réf - Code\_Aster : 0.89 %

Residual strength:

Valeur de référence :  $|\sigma_1 - \sigma_3|_{ref}^{rup} = 55.1249$

Valeur du Code\_Aster :  $|\sigma_1 - \sigma_3|^{rup} = 55.1249$  (numéro d'ordre : 81)

| Localization   | Sequence number | Forced (MPa)  | Code_Aster      |
|----------------|-----------------|---------------|-----------------|
| Point <i>D</i> | 18              | $\sigma_{xx}$ | - 25.00         |
|                | 81              | $\sigma_{xx}$ | - 25.00         |
|                | 18              | $\sigma_{yy}$ | - 25.00         |
|                | 81              | $\sigma_{yy}$ | - 25.00         |
|                | 18              | $\sigma_{zz}$ | -50.8398        |
|                | 24              | $\sigma_{zz}$ | -56.4340        |
|                | 36              | $\sigma_{zz}$ | -66.9436        |
|                | 46              | $\sigma_{zz}$ | <b>-75.3064</b> |
|                | 54              | $\sigma_{zz}$ | -77.6467        |
|                | 66              | $\sigma_{zz}$ | -79.7633        |
|                | 81              | $\sigma_{zz}$ | <b>-80.1249</b> |

| Localization   | Sequence number | Strain          | Code_Aster  |
|----------------|-----------------|-----------------|-------------|
| Point <i>D</i> | 18              | $\epsilon_{xx}$ | 1.85408 E-3 |

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|        |                 |             |
|--------|-----------------|-------------|
| 24     | $\epsilon_{xx}$ | 2.63445 E-3 |
| 36     | $\epsilon_{xx}$ | 4.35497 E-3 |
| 46     | $\epsilon_{xx}$ | 5.98034 E-3 |
| 54     | $\epsilon_{xx}$ | 7.90516 E-3 |
| 66     | $\epsilon_{xx}$ | 11.3535 E-3 |
| 81     | $\epsilon_{xx}$ | 16.7102 E-3 |
| 18     | $\epsilon_{zz}$ | -6 E-3      |
| 36.-12 | $\epsilon_{zz}$ | E-3         |
| 81.-27 | $\epsilon_{zz}$ | E-3         |

## 6 Summary of the results

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the got results show an agreement of stress  $\sigma_1$  the rupture and to residual strength between the computed values and those obtained with *Code\_Aster*.

This case test is a test of NON-regression developed to validate the model of Hoek-Brown modified.